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AFFIDAVIT OF ACCURACY

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I, the undersigned, being duly sworn, depose and state:

I am qualified to translate from the German language into the English language by virtue of being thoroughly conversant with these languages and, furthermore, having translated professionally from German into English for more than 8 years;

I have carefully read the translation appearing on the attached and said translation is an accurate, true and complete rendition into English from the original German-language text, and nothing has been added thereto or omitted therefrom, to the best of my knowledge and belief.

TRANSLATION ACES, INC.

Subscribed and sworn to before me this 12th day of April, 2001.

Karyn L. Tasens

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Commission Expires Oct. 31, 2002

[Translation from German]

January 1987

	Testing of Plastics **Determination of Heat Deflection Temperature Under Load**	**DIN** 53 461

Replaces version issued 09/69

See Notes for relationship to international draft standard ISO/DIS 75 – 1984 issued by the International Organization for Standardization (ISO).

1 Application and Purpose

1.1 The purpose of testing is to determine the heat deflection temperature of test bodies of specific dimensions that are subjected to temperature increases under constant bending load in a heat transfer liquid.

1.2 This Standard distinguishes among 3 different methods for determining the heat deflection temperature, which differ in the bending load applied (see Section 3.2 and Table 1).

Table 1

Method	Bending Stress N/mm² ± 2.5%
A	1.80
B	0.45
C	5.0

Standards Commission on Plastics (FNK) in the DIN Deutsches Institut für Normung e.V.
Standards Commission on Materials Testing (NMP) in the DIN

The method to be used for testing must be agreed upon in each individual case or defined in product standards.

Note: Method C is recommended for heat-resistant plastics whose heat deflection temperature according to Methods A and B is higher than the maximum operating temperature of the heat transfer medium.

1.3 The test can be used for plastics that are dimensionally stable up to a temperature of 27°C.

1.4 The values obtained in accordance with this Standard can be used for evaluating the behavior of plastics under bending load at temperatures above room temperature. It is only permissible to directly apply the test results to specific applications if the conditions regarding time, temperature and bending stress are similar to the conditions specified in this Standard.

The values obtained do not represent the maximum service temperatures, as these temperatures are a function of the variable influences mentioned above.

1.5 If no heat transfer liquid conforming to the requirements in Section 3.3 can be found for the plastic to be tested, the test method specified in this Standard cannot be used[1].

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[1] For use of air as the heat transfer medium, see DIN 53 462.

Note: If Method C (see Section 3.2) of the present Standard does not produce reasonable results for composite materials, such as combined pressboard per DIN 7739 Part 2, laminated plastics and reinforced plastics, please refer to "Testing of dimensional stability under heat" per DIN 53 462. Dimensional stability under heat of rigid cellular materials is tested according to DIN 53 424.

2 Definition of Terms

2.1 Dimensional Stability under Heat

Dimensional stability under heat is the capacity of a test body to largely maintain its shape up to a specific temperature under a specific static load. In this Standard, dimensional stability under heat is characterized by the heat deflection temperature.

2.2 Heat Deflection Temperature

The heat deflection temperature HDT per this Standard is the temperature at which the bending test body, which is supported on both sides in a heat transfer liquid and subjected to uniform, continuous heating, has attained a defined deflection — corresponding to an outer fiber strain of approximately 0.2% — under a specific centrally applied force.

Note: Test results are the heat deflection temperatures HDT/A, HDT/B, and HDT/C.

3 Test Apparatus

3.1 Test Set-up

The test set-up should correspond in essential respects to Figure 1 and comply with the requirements described in Sections 3.2 through 3.6.

3.2 Bending Device

The bending device consists of two supports and one bending die made of metal. The edges have a radius of curvature of (3 ± 0.2) mm. The support span is (100 ± 2) mm. It must be possible to apply the force in the center of the support span, perpendicular to the orientation of the test body, by means of the bending die. The vertical connecting pieces between the supports, and the cover that the deflection measuring device rests upon, must be made of a material that has the same coefficient of linear expansion as the bending die.

Note: If these parts of the test apparatus do not have the same coefficient of linear expansion, the differing changes in length of these parts produce a measurement error when the deflection of the test body is measured. The test apparatus should be tested with the aid of a rigid test body made of a material with a low coefficient of linear expansion in the temperature range in question. (Test bodies made of steel with a Ni content of 38% by weight, corresponding to types D1 and D1a per DIN 41 301, or made of borosilicate glass, have proven useful for this purpose.) If the measurement resulting from this test is ± 0.01 mm or larger, it must be added or subtracted when determining deflection per Section 5.4.

To produce the force, weights which apply a bending stress of 1.80 N/mm² (method A), 0.45 N/mm² (method B), or 5.0 N/mm² (method C) (see also Table 1) are used. When calculating the mass of the weights, it is necessary to account for the weight of the bending die and, if necessary, the measurement force of the measuring device used to measure deflection.

A set of a variety of weights is recommended to make it possible to set the necessary bending force (limit deviations ± 2.5%).

Note: In some configuration types of the test apparatus, the spring force of the dial indicator acts upward. The weights must then be heavier by an amount corresponding to this spring force. They must be lighter by a corresponding amount if the spring force of the dial indicator acts downward.

Since the spring force is a function of the measurement distance in some dial indicators, the force must be measured in the section of the measurement distance that is used.

The force F in N is calculated with the following equation:

$$F = (2\,a \cdot b \cdot h^2) / (3\,L_s)$$

where:

a is the greatest bending stress in the test body for methods A, B, and C in N/mm²

b is the width of the test body in mm

h is the height of the test body in mm

L_s is the support span in mm.

3.3 Immersion Bath

A suitable heat transfer liquid in which the test body can be immersed must be used for the immersion bath. The bath must have a stirring device. It must be possible to raise the bath temperature at a steady rate of 2 K/min (see Section 5.4).

A heat transfer liquid should be used that is stable at the temperatures employed, and which does not influence the properties of the test body.

Note: Polyglycol, paraffin oil and silicone oil have proven suitable in many instances; see the relevant standards for the plastic product.

3.4 Temperature Measurement Device

The temperatures are measured with 2 temperature measurement devices; tolerances G = 0.5 K. The devices must extend to the depth for which the tolerances apply, but no less than 50 mm deep.

3.5 Deflection Measuring Device

The measurement device must be capable of determining the deflection of the test body to 0.01 mm.

3.6 Linear Measurement Device

The linear measurement device must be capable of determining the height and width of the test body to 0.1 mm.

[Labels for diagram, page 2:]

Dimensions in mm

Cross-section A - B Cross-section C - D

weight

deflection measuring device

thermometer

cover

immersion bath

bending block

test body

support

Figure 1. Test set-up for determining heat deflection temperatures (example configuration)

4 Test Bodies

4.1 Shape and Fabrication

4.1.1 The test bodies have a length l of at least 110 mm, a width b of 3.0 to 4.2 mm, and a height h of 9.8 to 15.0 mm, with the exception of test bodies made of slab products, whose width b may be between 3 and 13 mm. The test bodies should be produced or sampled in such a manner that the force of pressure used in their fabrication has acted on the surface $A = l \cdot h$.

Test body dimensions deviating from these must be specified in the applicable standards for the plastic product or must be agreed between supplier and customer.

Note: The heat deflection temperature may increase by up to 4 K with increasing width and height of the test body in the ranges specified here.

4.1.2 If not otherwise specified in the relevant standards for the plastic product, or not otherwise agreed between supplier and customer, test bodies of thermosetting molding materials are produced according to DIN 53 451, and test bodies of thermoplastic materials are produced either through injection molding[2] or through compression molding[3] while taking into account the conditions specified in the relevant standards regarding molding materials.

The test results depend upon the manufacturing conditions of the test body and upon the pretreatment (for example, drying, temperature treatment, conditioning). Hence, precise specifications for these conditions are necessary in arbitrational analysis.

4.2 Quantity

At least 2 test bodies from each sampled product must be tested.

[2] See DIN 16 770 Part 2
[3] See DIN 16 770 Part 1

4.3 Pretreatment

The test bodies must be pretreated in accordance with the relevant standards for the molding compound or in accordance with the agreements between supplier and customer.

5 Procedure

5.1 Prior to testing, the width *b* and the height *h* are measured to 0.1 mm in the center of the test body.

5.2 The test body is placed on end on the supports (see Fig. 1). The temperature measurement devices are inserted in such a way that they extend to within 2 mm of, but do not touch, the test body in the vicinity of the pressure die. At the start of each test, the bath temperature should be 20 to 23°C unless preliminary testing has demonstrated that a different starting temperature does not cause any errors with the product under test.

5.3 The force calculated for methods A, B or C per Section 3.2 is applied to the test body.

After the load has been maintained for 5 minutes, the deflection measuring device is set to zero and the heat is turned on. The 5-minute waiting period can be omitted if the test body deflects less than 0.02 mm in this period of time.

Note: The purpose of the 5-minute waiting period is to partially compensate for the creep exhibited by a variety of materials at room temperature when they are subjected to the prescribed bending stress. The creep that takes place within the first 5 minutes usually constitutes the majority of creep occurring in the first 30 minutes.

5.4 The temperature of the bath is steadily raised by 2 K/min. There must never, at any time during the test, be a difference of more than 1 K between the specified and actual temperatures. The temperature at which the test body has achieved the deflection specified in the following table is the heat deflection temperature.

Table 2

Height *h* of the Test Body mm	Test Body Deflection mm
9.8 to 9.9	0.33
10.0 to 10.3	0.32
10.4 to 10.6	0.31
10.7 to 10.9	0.30
11.0 to 11.4	0.29
11.5 to 11.9	0.28
12.0 to 12.3	0.27
12.4 to 12.7	0.26
12.8 to 13.2	0.25
13.3 to 13.7	0.24
13.6 to 14.1	0.23
14.2 to 14.6	0.22
14.7 to 15.0	0.21

5.5 If the heat deflection temperatures of the two test bodies differ from one another by more than 2 K[4], additional tests must be performed, and the individual values must be given as the results.

In the case of semicrystalline thermoplastics[4] whose glass transition temperature lies between the starting temperature and the heat deflection temperature, it is possible that the deflection temperature function in the range of required deflection defined in Section 5.4 can be sufficiently flat in one of the methods defined in Section 3.2 (e.g., method B) that reproducibility and comparability[5] of the test method become very uncertain. In these cases, the test can only be performed with one of the other methods (e.g. method A or C) described in Section 3.2.

6 Evaluation

The average, rounded to 1 K, of the individual values is the heat deflection temperature HDT/A, HDT/B or HDT/C.

7 Test Report

The test report must make reference to this Standard and include the following information:

a) Width *b* and height *h* of the test body to an accuracy of 0.1 mm

b) Manufacturing conditions of the test body

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[4] ISO/DIS 75 – 1984 allows deviations of up to 5 K for semicrystalline thermoplastics. This provision was not adopted in the present Standard for the reasons described in Section 5.5.

[5] For definitions of reproducibility and comparability, see DIN 1319 Part 3.

c) Pretreatment of the test body; if necessary, description of the state

d) Heat transfer liquid used

e) Heat deflection temperature HDT in °C, rounded to whole numbers, and the Method used (A, B or C as described in Section 3.2). For example, if Method A resulted in a temperature of 82°C: HDT/A (DIN 53 461) = 82°C

– Individual values if more than two measurements were necessary per Section 5.5

f) External changes in the test body, if applicable

g) Any conditions deviating from this Standard

h) Test date.

Cited Standards

DIN 1319 Part 3	Basic concepts in metrology; Terminology relating to the uncertainty of measurement and the assessment of measuring instruments and measuring equipment
DIN 7739 Part 2	Laminated products; Combined pressboard for electrical insulation: types
DIN 16 770 Part 1	Testing of plastics; Preparation of specimens of thermoplastic molding materials by compression molding
DIN 16 770 Part 2	Testing of plastics; Preparation of specimens of thermoplastic molding materials by injection molding

DIN 41 301	Magnetic steel sheets; magnetic materials for transformers
DIN 53 424	Testing of rigid cellular materials; Determination of dimensional stability at elevated temperatures with flexural load and with compressive load
DIN 53 462	Testing of plastics; Martens method of determining the temperature of deflection under a bending stress
DIN 53 451	Plastics; Directions for preparing test specimens of thermosetting molding materials
ISO/DIS 75 – 1984	E: Plastics and ebonite; determination of temperature of deflection under load F: Matieres plastiques et ebonite; détermination de la temperature de fléchissement sous charge D: Kunststoffe; Bestimmung der Temperatur bei bestimmter Durchbiegung under Last

Additional Standards

DIN 53 487	Testing of plastics; determining the temperature of deflection as a function of temperature

Prior Versions

DIN 53 461: 06/61, 09/69

Revisions

The following revisions were made from the September 1969 version:

– Adoption of Method C with higher bending stress

– Adoption of new symbol — HDT — for test quantity

– Standard adapted to the international draft standard ISO/DIS 75 – 1984 (see also Notes)

Notes

The content of this Standard is consistent with ISO/DIS 75 – 1984.

This Standard deviates from ISO/DIS 75 – 1984 in the following areas:

1. No greater deviation among individual measured values is permitted for semicrystalline thermoplastics (See Section 5.5).

2. In contrast to ISO/DIS 75 – 1984, Method C with a higher bending stress was additionally adopted here to make it possible to test heat-resistant plastics, filled plastics, and reinforced plastics.

This Standard is limited to the comparison of dimensional stability under heat of plastics by means of a heat deflection temperature HDT/A, HDT/B or HDT/C measured under comparable conditions. The dependence of the heat deflection temperature on the size of the bending load can differ widely, depending on the type of plastic. Knowledge of the functional relationships can be essential in the selection of materials for applications with specific loads, and can be determined according to DIN 53 487 for example.

As part of the efforts to unify the test body, the ISO bar, 80 mm × 10 mm × 4 mm, was also tested for determination of the heat deflection temperature. As in the bending test per DIN 53 452, the ISO bar is placed flat on the two supports with a support span of 64 mm, and subjected to loading in the center. Preliminary comparison tests have demonstrated that the same heat deflection temperatures are achieved with the previous test body (placed on end on the two supports with a support span of 100 mm) as with the ISO bar.

International Patent Classification

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